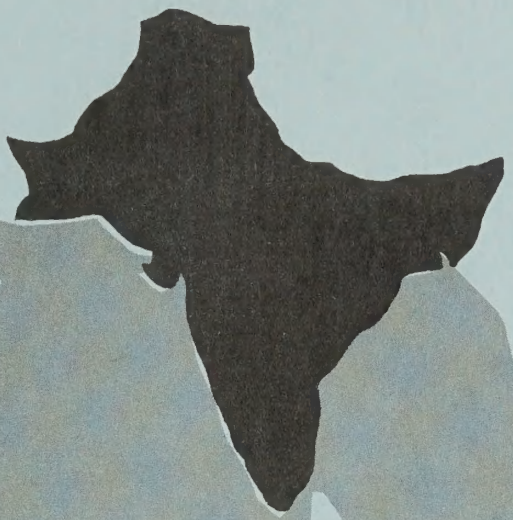
April, 1966



Agricultural Water Management in INDIA

U.S. DEPARTMENT OF AGRICULTURE
International Agricultural Development Service

A G R I C U L T U R A L W A T E R M A N A G E M E N T

IN

I N D I A

A Report

by

Soil Conservation Service Team

April, 1966

International Agricultural Development Service

United States Department of Agriculture

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ACKNOWLEDGEMENTS

A Land and Water Management Team from the Soil Conservation Service of USDA consisting of D. A. Williams, Ray Walker, John Sutton, and John Douglass visited India during the period of January 12-April 1, 1966. The study was requested by USDA under a Participating Agency Service Agreement. The team spent two months in India obtaining information and Indian viewpoints pertinent to formulating recommendations. During this time it was our privilege to talk with a large number of officials of the Government of India in the Ministry of Food and Agriculture, the Ministry of Irrigation and Power, and in the Planning Commission. These officials were very helpful in assisting with various arrangements and in making needed information available to us. In the five States visited we also talked with many State officials and received the same kind of courteous assistance. In addition, the States provided us with official escorts and arranged for our travel accommodations.

The team wishes to express its appreciation to the Government of India officials and to the officials of the States of Punjab, Uttar Pradesh, Maharashtra, Andra Pradesh, and Mysore for the assistance and courtesies extended.

The team also wishes to express appreciation for assistance received from the staff of the Agricultural Research Service, Ford Foundation, and the Rockefeller Foundation.

John P. Lewis, Director, USAID Mission, India, and his staff provided the necessary support assistance needed to carry out our assignment. We are especially grateful for this help. Dr. Olson and Messrs. Bauman and Madan, USAID Mission, provided special assistance in the collection and analysis of data included in the final report.

We were assisted materially in our field studies by Messrs. Leatham, McColm, and Boyd, USAID.

Basic Facts

1. For the foreseeable future, some two-thirds to three-fourths of India's cultivated lands (approximately 360 million acres) must continue to depend upon natural precipitation. The bulk of rainfall occurs during monsoon season (June-September) with frequent, very high intensities and storm quantities (8 to 12 inches). Generally, over the centuries, there has been practically no organic matter returned to the soil, and some of the soils are so compact that major runoff and flooding occur.

2. India's surface water supply from the Himalayas is great, and several major storage and irrigation canals have been developed since 1800. In recent years the United States, and some other countries, have made major grants and loans for these major works. However, very little attention has been given to proper water distribution and disposal from these canals.

3. There is a major ground-water resource under the Indo-Gangetic Plain, at the base of the Himalayas, in northern India. While there have been several thousand "tube-wells" installed during the past few years (many of them with U.S. AID and World Bank assistance), the real extent and dependability of this water resource are largely undefined. The proper use of the water from the wells has likewise received little attention.

4. There is a surprising lack of information as to the real adequacy of water supply and the suitability of soils for intensive uses.

5. Essentially no research on the interrelationship of soil, water, and plants has been carried out in India. Dependence must largely be placed upon extrapolated data from other countries.

6. There is practically no University instruction in agricultural water management provided in either the agricultural courses or the engineering courses.

7. Sedimentation of major reservoirs and canals from the denuded and highly erosive Himalayan foothills is a major problem.

8. Some 45 million acres of once-productive land are now so water-logged from lack of waste-water disposal and monsoon rains that productivity, if any, is very low. Approximately 25 percent of this area is strongly alkaline or saline. Perhaps half of the 45 million acres could be drained and rehabilitated at relatively low cost.

9. Perhaps a third of the 70 to 80 million acres under major canals and wells could be intensively irrigated and, in combination with fertilizers, good seeds, and soil management, could, under multiple-cropping, be made to produce four-fold more than at present. Yields from the balance and the "rain-fed" lands could, with improved management, be increased from 50 to 100 percent if the in-puts of fertilizer, etc., were judiciously achieved.

10. There is need for a much more effective agricultural credit arrangement.

11. The Central and State Governments need to fix organizational responsibility as well as policy and motivation to achieve any major impacts on water use. It is an inter-Ministry problem.

12. Cultivators need (1) irrigation and drainage systems that are properly designed, and (2) information on when and how to irrigate various crops.

13. There is a lack of depth of technical competence in the inter-relationships of soil, water, plant, and fertility management and in the training of India's technicians in this area.

14. Land ownerships are frequently so fragmented that land reform involving consolidations and control by cultivators is essential.

RECOMMENDATIONS

1. In order to determine the extent and quality of ground water supply in the Ganga plains, it is recommended that a USAID - U.S. Geological Survey PASA for ground water survey be negotiated.

2. In recognition of the need for more complete information regarding potential needs and opportunities for major irrigation and drainage development projects, it is recommended that AID give support to such a long-range study. It is understood that this proposal may be undertaken under the auspices of World Bank.

3. One of the basic needs for implementing a program of better water management is a corps of technically-trained Indian personnel in the field of soil physics, consumptive water use, and agricultural engineering and agronomic aspects of water management. To meet this need we suggest a USAID-University PASA for assisting agricultural universities to strengthen courses of instruction in these subjects.

4. Basic improvements in the efficiency of use of water on the farm offer opportunities for substantial increases in agricultural production in India. In order to offer major assistance in resolving some of the complex problems involved in bringing about needed improvements, a USAID/USDA/PASA is proposed for:

   (a) A three-year inventory of present water availability, drainage needs, and soil suitability for intensive agriculture.

   (b) Assistance to organize and motivate research in agricultural water management.

   (c) Assistance with development of procedure and policies for drainage development and consultant service on specific projects.

   (d) Assistance to organize and implement a more adequate agricultural credit program.

   (e) Assistance with organizing and implementing reforestation and grassland stabilization of highly critical sediment source areas.

   (f) Assistance in implementing a national cooperative center-state soil survey.

   (g) Leadership at Central Government by highly qualified water management expert and administrator for the PASA, and to lead inter-Ministry actions involving organization, policies, institutions, and programs. He should work closely with an official at the highest practicable level in both the Ministries of Food and Agriculture and Irrigation and Power.

(h) Comparable leadership at state level to (e) in three states.

(i) Massive pilot or demonstration areas, up to 100,000 acres in size in three areas to achieve comprehensive solutions to the problems of proper water management in combination with fertilizers, good seeds, improved cultural measures, land ownership adjustments, agricultural credit, and improved equipment. Such demonstrations should serve as major training areas for India's technicians. At least four technicians would be needed in each area for five to seven years. It could also involve U.S. rupees for incentives and Public Law 480-type assistance for labor forces.

5. It is recognized that short-term backstopping consultants will be needed, such as:

(a) technical and administrative specialist for essential support activities, and

(b) a practical well expert on design and equipment.

6. Arrange for the visitation to the United States of a small group (six to eight) of policy officials, probably at Secretarial level, from Food and Agriculture and Irrigation and Power to see a few examples of coordinated water use and soil management.

CONDITIONS FOR PARTICIPATION

Implementation of the aforementioned recommendations should be conditioned upon the following:

1. The GOI must be in agreement with any of the proposals to be implemented and be willing to designate a responsible official in the Ministry of Food and Agriculture and in the Ministry of Irrigation and Power with assigned responsibility for agricultural water management. This should include authority for making decisions and taking action. Such officials should work closely with the USAID/USDA PASA team leader.

2. In the States where special work is to be undertaken, a similar designation of responsibilities should be made, preferably in the Ministry of Agriculture. Such designated officials should work closely with the U.S. water experts assigned at State level.

3. At the demonstration project level an Indian official to serve as project leader should be designated and given administrative authority to enable him to make decisions and take necessary action to effectively carry-out the project. An adequate Indian staff should be assigned to the project on a full-time continuing basis. Arrangements for training assignments of three to six months for Indian technicians on the projects should also be provided.

4. The Government of India must be willing to make a substantial contribution to the operations costs of the demonstration projects if U.S. rupees are to be used in financing the work.

5. The responsibility for various segments of soil surveys such as correlation, interpretation, laboratory analysis, and mapping should be localized in one department with authority for one official to direct these activities. The official designated in this capacity should work closely with the soil scientist assigned to USAID/USDA team.

6. The GOI should designate appropriate officials to work closely with the consultants in river basin sedimentation and conservation functions.

RECOMMENDED U.S. GOVERNMENT TECHNICAL PARTICIPATION IN WATER MANAGEMENT ACTIVITIES

Activity	AID/USDA Agency Source	Location	No.	Position Designation	Approx. Grade Level	Duration	EOD	1967 Costs	Total * Annual Costs
Operations									
Water Conserv.									
Team leader	SCS	Delhi	1	Civil Eng.	17	4-5 yrs.	7/66	35,131	35,131
State leader	SCS	Unlisted	3	Conserv.	15	4-5 yrs.	10/66	70,060	93,414
Drainage Eng.	SCS	Delhi	1	Drain.Eng.	14	4-5 yrs.	10/66	18,902	25,203
Consultants									
Soil Conservation	SCS	Delhi	1	Soil Conserv.	14	2-4 yrs.	10/66	18,902	25,203
Soil Surveys	SCS	Delhi	1	Soil Sci.	14	2-4 yrs.	10/66	18,902	25,203
River Basin	SCS	Delhi	1	Sed. Spec.	14	2-4 yrs.	10/66	18,902	25,203
	FS	Delhi	1	Forester	14	2-4 yrs.	10/66	18,902	25,203
Credit	FHA	Delhi	1	Agr.Cr.Spec.	14	2-4 yrs.	10/66	18,902	25,203
Investigation									
Ground Water									
AID/USGS		To be determined				2-4 yrs.	ASAP		
Inventory AID/USDA	SCS	Unlisted	1	Irrig. Eng.	14	2-4 yrs.	9/66	23,090	27,710
	SCS	Unlisted	1	Cons. Agron.	13	2-4 yrs.	9/66	20,220	24,266
	SCS	Unlisted	1	Soil Sci.	13	2-4 yrs.	9/66	20,220	24,266
	ERS	Unlisted	1	Agr. Econ.	13	2-4 yrs.	9/66	20,220	24,266
Research	ARS	Delhi	1		14	2 yrs.	10/66	18,902	25,203
Teaching AID/Univ.		To be determined				2-4 yrs.	ASAP		

*Includes salary plus differential, plus other personnel benefits.

RECOMMENDED U.S. GOVERNMENT TECHNICAL PARTICIPATION IN WATER MANAGEMENT ACTIVITIES

Activity	AID/USDA Agency Source	Location	No.	Position Designation	Approx. Grade Level	Duration	EOD	1967 Costs	Total* Annual Costs
Demonstration & Training Areas									
Project #1 1/1/67	SCS	Unlisted	1	Irrig. Eng.	14	5-7 yrs.	1/1/67	13,855	27,710
	SCS	Unlisted	1	Cons. Agron.	13	5-7 yrs.	1/1/67	12,133	24,266
	SCS	Unlisted	1	Soil Sci.	13	5-7 yrs.	1/1/67	12,133	24,266
	ERS	Unlisted	1	Agr. Econ.	13	5-7 yrs.	1/1/67	12,133	24,266
Project #2 3/1/67	SCS	Unlisted	1	Irrig. Eng.	14	5-7 yrs.	3/1/67	9,270	27,710
	SCS	Unlisted	1	Cons. Agron.	13	5-7 yrs.	3/1/67	8,088	24,266
	SCS	Unlisted	1	Soil Sci.	13	5-7 yrs.	3/1/67	8,088	24,266
	ERS	Unlisted	1	Agr. Econ.	13	5-7 yrs.	3/1/67	8,088	24,266
Project #3 6/1/67	SCS	Unlisted	1	Irrig. Eng.	14	5-7 yrs.	6/1/67	2,310	27,710
	SCS	Unlisted	1	Cons. Agron.	13	5-7 yrs.	6/1/67	2,022	24,266
	SCS	Unlisted	1	Soil Sci.	13	5-7 yrs.	6/1/67	2,022	24,266
	ERS	Unlisted	1	Agr. Econ.	13	5-7 yrs.	6/1/67	2,022	24,266
Tube Well Expert		Delhi			15	6 mo.	Nov.	9,707	10,425
TDY's	SCS & others	Delhi	3 M/Y		15			31,280	62,555
								454,106	769,978
Supplies & Materials								5,000	10,000
Travel-details-PD								8,210	16,420
								467,316	796,393
15% overhead costs								70,097	128,460
								537,413	924,858

*Includes salary plus differential, plus other personnel benefits.

EMPLOYEES ON BOARD

	July 1966		Sept. 1966		Oct. 1966		Jan. 1967		Mar. 1967		June 1967		
	:Total		:Total		:Total		:Total		:Total		:Total		Total
SCS	1	3	4	7	11	3	14	3	17	3	20		20
ERS			1		1	1	2	1	3	1	4		4
ARS				1	1		1		1		1		1
FHA				1	1		1		1		1		1
FS				1	1		1		1		1		1
TOTAL	1	3	5	10	15	4	19	4	23	4	27		27

Estimated Demonstration Operations Costs for Practice Installation, Land Consolidation, and Equipment.

Assumed:

1. 10,000 acres project size

   a. land leveling

   b. irrigation ditches

   c. drainage ditches

   Total per acre - Rs. 600.00

2. Land consolidation

   Right of ways and equipment--
   per acre - Rs. 200.00

3. Total per acre Rs. 800.00

Per Demonstration Project

10,000 acres x Rs. 800 Rs. 8,000,000

Assumed:

Three demonstrations Rs. 24,000,000
Five-year period of installation,
or approximately 5 million rupees
per year.

Note: This would not include training costs for Indian technicians or overhead India and U.S. costs.

April 14, 1966

TO: Dr. John P. Lewis
Director, USAID Mission, India

FROM: D. A. Williams
Administrator, Soil Conservation Service
United States Department of Agriculture

SUBJECT: Report to Mission of Team to Assist AID in Determining What and How the U.S. Government can Constructively Assist India in Outlining a Program for Soil and Water Management on Farm Lands

At your request a team from the Soil Conservation Service of the United States Department of Agriculture has visited India from January 14, 1966 to March 31, 1966 for the purpose of the above noted subject.

No report has been prepared for the Government of India since the purpose was to make recommendations to our own government.

The attention of the team, as suggested, has focused primarily on water management as related to agricultural production. Specific attention was given to needs and progress in providing assistance on installation of farm irrigation and drainage systems, land levelling and other work essential to efficient use of irrigation water. Because the management of water cannot be disassociated from the management of land for agricultural uses, considerations of the inter-relationships of soil, water, plants, and people are all involved.

It is not the purpose of this report to again recount in detail the many problems with which India is faced in soil and water management. There have been several such studies made with previous

reports thereon. The report on India's Food Crisis and Steps to Meet It of April 1959; the report of TCM Consultant D. A. Williams of November 1960; the report on Land and Water Resources in India by a high level team in 1964, as well as the reports of several AID employees assigned to India have documented these problems and reference is made thereto. This team has considered all such reports as well as made its own field observations, held discussions with many officials of the GOI, and Rockefeller and Ford Foundations, and with various officials and other people in several states. The team is of the opinion that the above mentioned reports are accurate and the recommendations made therein are sound.

The question now deals with implementation of corrective measures in India and as to the nature and scope of U.S. Government participation.

Appended to this report are notes prepared by U.S. Madan as to the implementation so far by India of the recommendations made in 1960 by D. A. Williams.

Before specifically dealing with the water resources and their use and management, it should be noted that in the foreseeable future some two-thirds to three-fourths of the cultivable land in India must continue to depend on natural precipitation and is likewise subjected to the intensities of storms which result in major run-off and flooding. Problems related to these soils were observed by the team but no attempt was made to study them in detail. It is vitally important, therefore, that these rain-fed lands receive more, not less, attention as to the conservation and management of the precipitation

that falls on them. With proper soil management and conservation treatments, soils of good depth can store precipitation sufficient to assure crops in normal years. Without such treatments the water escapes without entering the soil profile.

As previous reports have cited, the rates of sedimentation of reservoirs, stream-beds, and canals from many of the catchment areas above are very great. The length of life of some reservoirs is of great concern as one looks to future water needs. Recent estimates by Central Water and Power Commission* of sedimentation into the Bhakra Dam reservoir are in excess of 28,000 acre-feet annually. It continues to be, therefore, a matter of urgency that appropriate reforestation and other critical area stabilization measures be employed. Because of this situation, the team suggests the desirability of including on the USAID Contract Staff a conservation forester and a sedimentation specialist to give continuing attention to this matter.

Water Resources

As documented in various reports of the GOI, and consultants, the surface and ground-water resources of India are great but they are not equally available to all of India and cannot be economically so developed. For more than a century there have been major developments of storage of water and canals for irrigation water delivery. While most of these developments exhibit some remarkable feats of engineering construction, they have been designed for an extensive

*Soil Conservation vs Sedimentation of Bhakra Dam, Published by Central Water & Power Commission, 1965, page 55

rather than intensive agricultural development. Generally major schemes have been built for famine relief with available water to be divided among areas and villages in the command areas.

Most or all of them were not built to deliver water to the right land at the right time and the right amount for intensive irrigation. Water has been delivered to village groups and divided among the cultivators. Some systems, at least, have only about one-fourth of the capacity needed to serve the intended command area and lack of water-control devices adequate to assure the delivery of appropriate heads of water at the right time and place.

In many systems water is not delivered to each bund but the overflow from a bund is used to irrigate the next lower bund and so on down the slope. Where ownership is divided the upper owner has a great advantage when water is short. On many systems land is not levelled properly and wild flooding is used to irrigate crops. Thus it is apparent that the control of irrigation water from the canals is far beyond the reach of the cultivators.

Canal leakage and wasting of water, which cannot now be efficiently delivered to the fields for use, coupled with run-off during the monsoon season, has resulted (because of the lack of disposal systems) in an estimated 45 million acres of water logged land of which about 20 million acres are affected by salt.

For alluvial areas of Northern India there is an immense ground water resource which, during recent years, has been tapped with thousands of tubewells under State and private development.

Investigations to date by GOI and ground water geologist consultants, while generally of reconnaissance or preliminary nature, do not show any diminishing of the ground water table as a result of the pumping. However, the extent and characteristics of the ground water resource subject to economic development are not well defined. Pumping of tube-wells has, however, supplemented canal water in many command areas and provided the only irrigation supply in many minor and individual areas.

Intensification of agriculture is taking place in some instances where an ample supply of water, controllable as to time and place, is available. It is thus possible in such instances to balance cropping systems, good seeds, fertilizers, and management techniques consistent with soil capabilities and without water being the limiting factor to increased crop production. Climatically most of India can produce multiple crops on the same acreage under these conditions. On the other hand on much of the irrigated land these conditions do not exist. Water is not available at the right time and in sufficient quantities, neither does the cultivator have adequate facilities for properly utilizing available supply. Under these conditions the lack of proper water management becomes the basic limiting factor in crop production. Perhaps, therefore, the principal means by which crop production may be increased in India is in areas where water can be managed so that it is not controlling whether that be from irrigation, drainage, or flood alleviation. To that end India's policy, administrative, and technical resources should be geared.

It appears that insofar as water management is concerned the quickest results in improved crop production can come from (1) more efficient distribution and application of presently developed water supplies, (2) drainage of waterlogged but not excessively alkaline areas where outlets are available, and (3) development and energizing of tube-wells to provide water for full-year use.

Agricultural Use of Water

The first step to achieve efficiency in better utilization of water on the farm is the installation of properly designed irrigation and drainage systems to permit proper application of water and removal of excess water. The system should include adequate ditches, bunds and other structures which will permit the control of irrigation water and disposal of excess water not used for consumptive crop use. The land must be levelled and shaped to permit the uniform application of water over the field.

There is little available information on water requirements. Farmers must reply on local practices to determine how they should irrigate crops. The current programs of State Governments have given some assistance on installation of individual irrigation systems. Such work has largely been directed towards assisting farmers to bring land under irrigation in the new irrigation projects. This work needs to be strengthened. Modern construction equipment is needed.

Irrigation and drainage guides need to be developed where specifications for adequate systems will apply to local conditions.

The requirements for water management systems and preparation of technical guides is discussed more fully in the appendices to this report.

There have been examples in localized areas of the interest of cultivators and district technicians and of some State officials to achieve proper irrigation water management. The impact of the work of present AID employees McColm and Leatham and of former AID employees has aided in achieving on-the-ground examples of the benefits of efficient water managment to increased crop production. That impact, however, appears to be local, and too poorly understood or appreciated in wider areas or at State and central levels. The lack of continuity and organized government support has limited the effect of these good efforts.

The Tubewell Development

Thousands of tubewells have been installed by State governments and by private development in recent years. Most of those in Ganga River System plain have tapped a dependable water supply of good quality. Unfortunately many of these wells have not been energized and electricity is not now available. Diesel engines and tractor power are in limited supply. The practical difficulties of keeping oil engines operating make it desirable to install electric motors. The practical limitations of large-scale tubewell development are, at present, apparent. Little attention has been given to efficiency of tubewells. The discharge of several wells appeared low compared with pipe size. The reports indicate stoppages were frequent and

repair parts difficult to obtain.

It is recommended that the services of an expert on well design and installation be supplied to more fully determine the needed improvement in tubewell design and installation and to advise GOI thereon. This should include pump efficiency tests as well as study of screen and gravel packs. This could be handled by at least one consulting firm now in India or, if possible, a USAID arrangement could be worked out to obtain the services of an expert in this field.

Electric power should be supplied to operate wells. Drilling equipment and efficient pumping equipment would need to be supplied in quantity to increase the rate of installing tubewells.

Drainage

Drainage problems result from waterlogging of irrigated lands and from flooding due to monsoon rains. Some major drainage canals have been constructed by the Irrigation Departments of State governments. Limited work has been done on farm-type drains, however in most areas drainage work has been neglected.

The Fourth Five-Year Plan provides for substantial work in drainage. Effective work in this field offers means of increasing agricultural production. The need for providing training in drainage investigation and design methods is evident.

The team suggests that when the GOI provides for an engineer to assume leadership in this field, USAID/USDA PASA team should include a drainage engineer to provide assistance in investigation,

criteria and specifications and to provide technical leadership to demonstration projects.

Water Management Research

Little research on the inter-relationship of soils, crops, fertilizers, and water has been done in India. There is little direct information available on consumptive water use in agriculture except that extrapolated from data from other countries and from experience of cultivators or technicians. Obviously, the need for such research is very great. But that is long-term in nature.

An immediate plan for a research program to systematically make provisional consumptive use estimates based upon meteorological data for the major irrigation crops in each climatic zone should be made. A similar type of rapidly applied research should be made to develop criteria for farm irrigation methods, systems and layout which are adapted to India's conditions of small fragmented holdings, small irrigation streams, and cultural methods. These are jobs that Utah State University, California University, or the Agricultural Research Services of USDA might help India do.

There are some favorable indications pointing toward the development of water research activities. The GOI in its Fourth Five-Year Plan proposes inaugurating research work. The Rockefeller Foundation contemplates some activity. To that end the USAID may well serve an important function as a catalyst and advisor, by providing a water management research specialist at the headquarters in New Delhi.

Teaching at Agricultural and Other Universities

The very great significance of agricultural water management to the agriculture of India and to its crop production strongly points to the need for under-graduate and post-graduate instruction at the agricultural universities. There apparently is very little direct instruction in this area. The whole area of soil physics and consumptive water use and the agricultural engineering and agronomic aspects of water management needs much more attention. Perhaps these types of training should be closely related to water research at the Universities. Consideration might well be given to a USAID-University contract with such an institution as Utah State University, or the University of California at Davis. There is an immediate need for a large number of engineers trained in fundamental engineering and irrigation and water management. There also is a need for a university curriculum for training soil scientists.

At the Universities teaching Civil Engineering, it would be desirable to include courses in the basic relationships of soil, water, and plants for engineers being trained for irrigation and drainage work.

Policy on Water Use

Several U.S. consultants have heretofore pointed out the urgent need for policy development and motivation to bring water development, use, and management into effective being in India. That need still exists. However, there seems to be a growing appreciation of this need by the GOI.

If India is to move forward at a rate anywhere near consistent with its need for intensification of agricultural production it must adopt at the Ministerial level and motivate throughout the Central, State, District, Block, and Village levels some effective policies on land and water use.

Such policies must take into account land capability, priorities of water use, allocation of resources on a selective basis, coordination of public works with intensity of agricultural objectives, land ownership adjustments and consolidations consistent with land and water management objectives, and definitive fixing of organizational responsibility for efficient administration.

Future U.S. Government involvement of major significance in developmental activities relating to land and water might well be conditioned upon the adoption of such policies and strong evidence of motivation. For example, substantial financial inputs by the U.S. in major or minor water projects might well require that water management opportunities will be built into the systems so that intensive agriculture can and will develop. Such a requirement might include (1) a thorough evaluation of policies and criteria for selection, design, and operation of water projects, and (2) a well organized and scientifically based water management program for assistance to cultivators.

Organizational Considerations for Land & Water Activities

Several U.S. consultants as well as Indian officials have recognized the need for organizational streamlining and fixing of clear-cut authority for land and water developmental,

conservation, and use activities. The team found that responsibilities for complete soil conservation activities are divided among several GOI and State agencies. There appears to be general lack of understanding of a broadened and coordinated concept of soil conservation that includes all the combinations of soil and water management practices necessary to increase agricultural production. There is no agency responsible for preparing a soil and water conservation plan and for providing assistance on all these measures needed on the land. Very little assistance is available to farmers on water management practices and farm drainage work is usually neglected.

At the present time, with a few exceptions, there are no qualified irrigation engineers working in water management in the Agricultural Department. Furthermore, the Department has no organization or position set up to provide for use of such engineers. If better students are to be encouraged to qualify for this field of work, the Ministry of Food and Agriculture should establish appropriate positions to utilize them. It should recognize the need for establishing a staff of engineers in the Department. Salaries, opportunities and other incentives should be commensurate with engineers in other fields. In this regard, special attention is called to the recommendations on Organization contained in the November 1960 report of Consultant D. A. Williams to the Government of India.

Soil Surveys

Soil survey investigations have been carried out in India for the past 50 years. Progress has been made in respect to a modern scientific and agriculturally oriented approach. Dr. Charles E. Kellogg made important suggestions in 1958 and in 1959 for the soil survey program. These suggestions are still pertinent.

A need exists to improve relationships between the GOI, State, and local soil survey agencies and to improve cooperative relationships between the soil survey and existing agencies for special assistance in agronomy, forestry, engineering, and economics. By integrating good soil survey information with data on crop yields, fertilizer response, forestry, hydrology and other engineering aspects, useful interpretations can result for improved soil and water management by kinds of soils.

Lack of adequate soil surveys is a limiting factor in present agricultural planning. Soil surveys are sometimes made after large scale irrigation projects are completed. This should be reversed in the future so as to permit proper land use planning in the development stage of projects.

The completion of detailed standard soil surveys on potential farm land, although important, will take a long time. Currently, strong support should be given to the development of a cooperative Center-State standard soil survey to serve all users and to coordinate soil testing laboratories with the soil survey program. Further principles for the soil survey program are outlined briefly in the appendix.

The team recommends that a staff soil scientist with particular capabilities in soil interpretation be included as a member of the AID/USDA/PASA team with headquarters at New Delhi. The function of the position would be to maintain continuous liaison with GOI on soil surveys and to relate the results of research and of farm experience elsewhere in the world to similar soils in India.

Consolidation of Land Ownership

One of the principal bottlenecks to efficient water management, both disposal systems and irrigation, is the scattered pattern of land ownership and the physical obstacles such as boundary bunds which frequently prevent effective water distribution. There would appear to be several alternatives to approaching this problem, no one of which may be the complete answer. Among them are:

1. Voluntary exchanges of property without compensation resulting from educational efforts in the blocks and villages. This approach does not appear to achieve needed results.

2. Adjustments in ownerships and physical features with technical guidance and persuasion at village level and adapted to essential physical features such as contour bunds, irrigation, and drainage channels or devices. So far this approach has apparently not been effective.

3. Incentives of financial assistance and compensatory payments to induce land consolidations in village areas in accordance with technically sound schemes of water distribution and disposal.

4. Acquisition of land holdings by government followed by its development and resale on a desirable pattern to the same or new owners. This approach may be fraught with many undesirable practical difficulties.

There would appear to be merit in demonstrating the Number 3 alternative in a substantial way in several areas. Perhaps the allocation of U.S. rupees to be granted to the village Panchayat for compensating landowners for out-of-pocket costs of adjustments might be worthy of serious consideration for pilot or demonstration village areas. Such compensation would be in addition to any subsidies provided for the costs of land grading and water control structures plus the initial investment in a few animal-drawn and small power-drawn earth moving implements.

Institutions for Water Distribution and Removal

Mr. Hatt of Ford Foundation pointed out in February 1962 that "Many groups of cultivators whose water problems require community action lack qualified institutions through which the necessary actions can be taken. In many States there is no official department nor qualified unofficial institutions responsible for distribution, disposal and administration of water between the State constructed and operated works and the individual cultivator's fields. If responsibility for these functions is to remain with the cultivators, organizations with certain specific legal powers and responsibilities are needed. Such institutions can be constituted and operated in accordance with democratic principles. At the same time, their officials must be empowered to take decisive actions in the face of

some opposition, whenever that is necessary for the common good. It is unrealistic to expect that solutions to complex village water distribution and disposal problems can be formulated which will be completely satisfactory to all the affected cultivators. It is even more unrealistic to expect that each member of a large group of cultivators can be induced through ad hoc arrangements to meet his obligations for construction, maintenance, and satisfactory operation of the works which serve a large group. In the long run some type of organization is needed with responsibility for village water control whose officials have specific powers (1) to secure rights of way for improvements; (2) to commit its members to financial and other obligations required for construction and maintenance of community irrigation and drainage works; (3) to enforce equitable distribution of irrigation water; and (4) to represent the members in dealings with officials of various departments. It would seem logical and consistent with policy to provide the authority and resources necessary to cope with these group water problems to the Village Panchayats, but as of now that action has not been taken in all of the States."

Our team fully subscribes to this quoted statement.

A Place for Demonstrations

"Seeing is believing." Such is the purpose of demonstrations. The vastness of India, or any one State or District thereof, precludes quickly doing everything needed everywhere. But there is a positive need for demonstrating the solution to community water distribution and disposal problems in addition to assisting

village cultivators achieve improved water management. Community-type demonstrations might well encompass the entire village area; the area served from the outlet of one canal or tubewell; an entire natural watershed, or other logically selected area. Included in the demonstration might well be the essential land consolidation, the assurance of an adequate water supply for intensive multi-crop production, institutional arrangements, water disposal and distribution systems, land grading and water control structures, and management of water consistent with soil characteristics and crop requirements. Such demonstrations might well be conducted in intensive agriculture districts so that the combined inputs of improved cropping, seeds, and fertilizers could be used along with appropriate water management. The crop production and economic values should be appraised as a part of the demonstration.

One of the major functions of the demonstrations would be to assist with training large numbers of Indian technical personnel in the techniques of land shaping, irrigation ditch layout and drainage. Such training should be aimed at developing an appreciation of coordinated planning in the field of soil, plant, and water relations. It should contribute to the development of a technical staff which would command the respect of all departments working in the field of water development and management. Such training should include both professional and sub-professional workers.

It is believed that the value to Indian agriculture of such demonstrations would warrant a major input of USAID resources in three or four selected areas over a period of five to seven years. (Such areas might coincide with areas selected for Ayacut development under a recent GOI proposal.)

Investigations, Studies, and Research

1. A proposal is currently under consideration in Punjab State for investigations, to be financed by a World Bank loan, essential to planning future agricultural development in that State. "The purpose of the studies is to enable the Punjab Government to make more rational decisions as to the development of its agriculture." The proposal would involve leadership by the U.S. Bureau of Reclamation and is estimated to extend over a three-year period. The estimated time involved is "(1) an integrated phase of initial appraisal lasting six to nine months, (2) reconnaissance survey and study phase (18 to 24 months), and (3) a final phase of evaluation and plan preparation lasting six months."

Such an investigation in the Punjab, if agriculturally oriented, should meet a specific need in Punjab, and in principle, should benefit other areas in India.

2. A proposal for ground-water resource investigations in Uttar Pradesh State may evolve from a current World Bank sponsored study team working in that State. Such an investigation would likely involve determination of the sources, extent, and capabilities for tubewell development as a major source of water supply.

Such an investigation which would likely extend over a five-year period could be considered as an appropriate USAID-sponsored PASA arrangement with the U.S. Geological Survey or may involve a World Bank loan arrangement with Uttar Pradesh State.

3. Our team proposes a three-year inventory, in cooperation with the Central Government and the States, of the areas in India having an adequate supply of irrigation water to permit intensive agriculture and of areas where water disposal by drainage would permit intensive agriculture. This could include an appraisal of operating experience of tubewells in Uttar Pradesh. A resident team consisting of a conservation irrigation specialist, an agricultural economist experienced in irrigated agriculture, an agronomist or crop specialist likewise experienced in irrigation, and a soil scientist capable of soil interpretations of irrigability and drainability of soils. Such a team might be provided under a USAID/USDA PASA agreement.

Policy, Organization, Institutions, and Operations Assistance by the U.S.

1. USAID-USDA-PASA Proposals:

a. Water Use Consultant - New Delhi

There is urgent need of a top-grade water use consultant to communicate officially with high level technical officers and administrators in the Ministries of Food and Agriculture, Irrigation and Power, and Community Development as well as the Planning Commission, on matters of water policy, institutions,

organizations, investigations, and project proposals. Because of the need for a prestige individual and organizational affiliation, the incumbent should have a reputation in the water field, should probably be an agriculturally oriented civil engineer, be adept at human relations, diplomatically aggressive, and willing to serve from 4 to 5 years. The position should also serve as the general leader of the USDA-PASA Water Management Contract.

b. Water Use Consultants - States

It is proposed that three high-quality consultants be selected to work at the State level -- in selected States -- to perform comparable functions at that level to the Consultant at Central headquarters. The duration of such positions should be not less than two years.

c. Water Management Teams at District Level

It is proposed that teams consisting of not less than 4 men each (Agricultural Engineer, Soil Scientist, Agricultural Economist, and Conservation Agronomist) be headquartered at selected field locations for the purpose of helping to conceive, develop, and carry out demonstrations of water distribution, disposal and management as heretofore described. The determination of the exact composition of the teams would be based upon the problems involved in each specific project area.

In addition to the teams it is proposed that AID be prepared to commit rather large blocks of rupees to compensate for land use adjustments, subsidize irrigation and drainage improvements and purchase appropriate equipment.

d. Agricultural Credit Specialist - New Delhi

Costs of the necessary earthwork and small structures for improved water management will exceed the available capital of many cultivators. Many cultivators will require medium- or long-term credit that is not generally available now for these purposes. This need, coupled with a broader agricultural credit need, implies the need for a credit specialist experienced with irrigation agriculture to serve as an advisor to the GOI on agricultural credit. This position might well be included in the AID/USDA/PASA staff at New Delhi.

e. Conservation Forester - New Delhi

As cited in this report, there is need for greater attention to the problem of sedimentation in reservoir and other catchment areas. The services of a forester experienced in watershed management is proposed for a period of two years to add stimulation to this needed activity. He would also serve as an advisor on village plantations of trees for fuel purposes. Such a position should likewise be considered in the AID/USDA/PASA.

f. Short-term Backstopping Consultants

Any USAID-Agriculture PASA arrangement should appropriately provide for essential supporting expertise and for administrative supervision of the activities contracted. Team or individual assignees should not be cut loose from essential backstopping even though they must be given the maximum latitude to operate within their fields of competence.

Official Visitations

The implementation of proposals in this report will require the full support and active participation of the Indian Government. Officials of the Indian Government will necessarily become involved in decisions of difficult and complex nature. In order to facilitate their understanding of the problems involved, we suggest that consideration be given to encouraging the visitation to the United States of a small group of high officials, probably at the Secretarial level, from the Ministries of Food and Agriculture and of Irrigation and Power. The group might also include a few selected officials from States that will be participating in projects. An opportunity could be provided for the group to visit a few areas to observe examples of coordinated water use and soil management.

D. A. Williams, Team Leader

Ray Walker

John Sutton

John Douglass

Implementation of Recommendations
Made by D. A. Williams, 1960

This statement includes quoted recommendations from the 1960 report of D. A. Williams followed by comments of appraisal prepared by U.S. Madan in March, 1966.

All India Land Use and Soil Survey Organization

Recommendation: "Soil surveys should be the responsibility of the Soil and Water Conservation organization at the Central and State levels of Government."

This has not been implemented. In the States also, soil survey is with the Agricultural Chemist and is not the responsibility of the state soil conservation organization. At the Center it is under consideration to make the Advisor, Soil Conservation responsible for soil survey both technically and administratively.

For the Fourth Plan it has been agreed that Center will undertake survey of IADP areas in addition to the survey of River Valley projects.

Package Program

Recommendations:

1. "The Package Program in selected districts offers real hope of demonstrating ways and means of accomplishing at least some of the conservation program objectives."

(Soil and Water Conservation program is not included in the IADP or IAA Districts.)

2. "Soil and Water programs must be technically rather than politically oriented."

(This has not been fully followed.)

3. "The research must be of the practical or applied kind, as well as fundamental, in proper balance."

(This has been implemented.)

4. "It is of utmost importance that technically trained people be permitted to advance in career programs of their chosen field rather than shifted about, thus dissipating their talents."

(Not implemented.)

5. "Bold aggressive actions are needed. Administrators with fixed responsibilities are essential for positive results. Adequate accomplishments will not be obtained unless the administrators are technically oriented in their fields of responsibility."

(Practically nothing has been done to follow or implement this most important recommendation.)

Consolidation of Holdings

Recommendation: "It is therefore urged that conservation experts work very closely with officers dealing with consolidation and that consolidation of holding policies be adopted by the Center and State governments to facilitate conservation objectives."

(This most important recommendation has unfortunately not been cared for or implemented. When the High Level Team visited Andhra Pradesh and had discussions with the State officials regarding consolidation, it was suggested that the soil survey man be associated with the consolidation staff and their reply was that revenue officials are competent enough to classify land.)

Decentralization

Recommendation: "A higher degree of decentralization of authority and responsibility for administrative and technical decisions appears desirable to expedite assistance to cultivators and the application of conservation practices on the land."

(Not implemented.)

Demonstrations

Recommendation: "It appears highly desirable that such demonstrations be carried forward by the Central Government until they have fully served their purpose or the States are adequately organized to maintain them."

(This recommendation has been adopted and great attention is being given to proper demonstration works.)

Financial Assistance

Recommendation: "Public financial investments in land use adjustments and in conservation practices with long-term public benefits appears essential to the accomplishment of the essential soil and water conservation program."

(There has been no change in the financial pattern except that for centrally sponsored scheme of soil and water conservation program in 14 River Valley Projects in different States, Center provided funds outside the State plan ceilings and grant (subsidy) is 50% instead of 25%.)

Drainage - Waterlogging

Recommendation: "Because drainage is to primarily serve an agricultural purpose, the planning of it should be participated in by agricultural experts. It is suggested that a top expert or experts in agricultural drainage be sought as consultants for several months on this problem."

(According to my information no expert in agricultural drainage has come to Punjab. Irrigation Department (Punjab) has prepared Master Plan of drainage for Punjab and has developed a high organization with Suptd. Engineers, Executive Engineers, Sub-Divisional officers, with supporting technical staff. But no action or steps have been taken to have any scheme or proposal for surface drains from agricultural lands.)

Minor Irrigation

Recommendation: "Tubewells' widespread use without adequate determination of feasibility should be discouraged."

(Care is being taken of this recommendation. In this connection recommendations of High Level Team's report (pages 21-24) may be pursued.)

Reclamation of Alkaline and Saline Soils

Recommendation: "This problem must be approached on a technically sound basis. To attempt to reclaim such lands in areas of low rainfall and little if any irrigation water will be costly and in most cases disappointing."

(There has not been much work done in the country in reclamation of alkaline and saline soils; nor is any big program anticipated in the Fourth Plan.)

Torrent (Choes) Training

Recommendation: "Close coordination is essential between agriculture and irrigation or public works experts to achieve satisfactory plans."

(There is still no coordination between different departments 'disciplines' - Irrigation, Forests, Agriculture, Community Development.)

Cultivation on Steep Sloppes of Himalayas

Recommendation: "It would appear that the steep slopes of the Himalayas cannot continue in cultivation if this siltation problem is to be solved."

(Faulty cultivation without adoption of soil and water conservation measures on steep slopes continues and there has been no change in the policy.)

Improvement of Grassland (Pasture Development)

Recommendation: "Such improvement necessitates the boldest of administrative action in the restriction of grazing use until recovery occurs and the management of grazing use thereafter consistent with desired vegetative types and their sustained vitality."

(Uncontrolled grazing continues and there is no program of rotational grazing. Reference may be made to the High Level Team's report (pages 34-36) regarding 'Wastelands and Grazing Lands'.)

Lining Canals

Recommendation: "Lining of canals through soil areas of medium and heavy textures should be of lower priority than the provision of drainage and reduction of wastage of irrigation water."

(More attention is being paid to drainage problem and reduction of irrigation water, but this recommendation still requires a much better program.)

Contour Bunding Program

Recommendation: "Thus a technical foundation is essential to the solution of such problems."

(Contour bunding program still continues to be without care of soil survey or land classification and whether the land has proper depth of soil for cultivation. The existing program is based to achieve physical targets and is not technically oriented.)

Aerial Photographs

Recommendation: "It is suggested that wherever possible aerial photos be obtained and that the making of topographic maps by field workers be reduced."

(This recommendation is being followed, especially for watershed management. Aerial photographs of river valley projects have been made, and use of these as base maps is being made. For Fourth Plan decision has been taken that vulnerable areas as per aerial photographs be first surveyed.)

Ravine Reclamation

Recommendation: "It would seem more logical and practical to detain or divert the over-burden water from such areas, exclude all grazing, and reforest the critical areas."

(There has been change in the thinking in regard to reclaiming ravine lands for cultivation. More stress is for closure and afforestation and control of water by having diversion channels.)

The Follow-On Practices in Contour Bunded Areas and Use of Broad Base Terraces

Recommendation: "It is essential that conservation workers follow through with cultivators to achieve the application of needed practices and become conservation farmers. More attention should be given to the use of broad-base terraces in lieu of bunding."

(Still no care is being given to "follow-on" practices. There is no provision for water disposal or grass water ways.)

Bunding work is in reality field bunding or property demarcation and not on contour. No where have broad base terraces been developed.)

Coordination of Program Planning in River Valley Catchments

Recommendation: "Programs should be multi-purpose in nature."

(On paper it has been agreed to have coordinated schemes for soil and water conservation works in all types of lands lying in the catchment, but in practice the recommendation is not being fully implemented. There is change for better but there is further scope for full coordination.)

Protection of Terraces, Bunds, Drainage Channels, and Vegetative Treatment

Recommendation: "The protection of constructed terraces, bunds, drainage channels, and vegetative treatments from excessive livestock grazing and trampling is a must if the soil and water resources are to be conserved and improved."

(There has been no improvement or change since 1960. Number of useless cattle has increased and it is becoming a serious problem. Canal banks, tank banks, etc., have rills and gullies due to heavy grazing.)

ORGANIZATION

Village Level

Recommendation: "A second VLW is assigned to deal entirely with agriculture and primarily with soil and water conservation."

(There are 20 VLWs in each block against normal number of 10, but none of them is trained in soil and water conservation program. Neither does the block program include soil and water conservation program, including grading of land or proper water use.)

Block Level

Recommendation: "A soil and water conservation officer should be assigned at the block level to work on conservation education."

(No extension officer for soil and water conservation program is on block organization. In no area is a Panchayat committee formed on soil and water conservation.)

District Level

Recommendation: "To provide a soil and water conservation officer in each district."

(This is being implemented. The recommendation of tenure and career opportunities is not being followed.)

State Level

Recommendation: "To have Joint Secretary of Agriculture for Conservation and in addition, to have State Conservator of Soil and Water Conservation along with officers on conservation planning, soil survey, engineering, training, agronomy, forestry and research liaison."

(In spite of the best efforts of the Center the States do not have an integrated organization for soil and water conservation program. As in 1960 the soil and water conservation program is being carried out by the Forest Department in forests and wastelands and the Agriculture Department in agricultural lands without any integration or coordination with Irrigation Department. Even in Irrigation Department minor irrigation and drainage are not being coordinated.

In some States Secretary of Forests and of Agriculture is the same person while in other States there are separate Secretaries for forest and agriculture departments and, as such, there is no chance or possibility of an integrated program. Planning departments of States are supposed to bring about the coordination, but in practice there has been no change.

In most of the States there are Soil Conservation Boards or Land Improvement Boards but they are more advisory in nature than functional.)

Central Government Level

Recommendation:

"1. Joint Secretary for Agriculture for Conservation;

2. Central Conservator for Soil and Water Conservation along with a supporting team of:

(a) Director of Conservation Planning
(b) Director of Training
(c) Director of Research
(d) Director of Soil Survey
(e) Director of Engineering
(f) Director of Agronomy and Range Management
(g) Director of Forestry
(h) Director of Program Inspections
(i) Director of Conservation, Information and Education."

(This recommendation has been partly implemented. Joint Secretary as before is an administrator and not a technical man and is responsible for other programs and not only for soil and water

conservation. From 1961 the following staff is functioning:

1. Soil Conservation Advisor to MFA
2. Deputy Advisor (Forests)
3. Deputy Advisor (Research and Training)
4. Deputy Advisor (Inspection and Coordination)
5. Deputy Advisor (Engineering)
6. Assistant Advisor (Soils and Agronomy)

The same number existed before 1961 but with different names: 3 Directors and 3 Deputy Directors.

The present staff works in an advisory capacity and has not been given full authority or responsibility for the soil and water conservation program. According to the recommendations there should have been an independent directorate for soil and water conservation, but in practice the administrators who are non-technical persons like Joint Secretary, Deputy Secretary and Under Secretary, have the main responsibility and role in the program.)

SOIL SURVEY

Good soil survey information can make a useful contribution to the various programs designed to increase farm production throughout India. Many of the field workers have not learned how to use the soil survey information presently available in India for soil selection and use in either the planning or execution state of soil and water management projects. Some field workers variously consider a soil map to be simply a soil erosion map, a soil fertility map, a soil texture map, a land capability map, or other single factor or interpretative map. Present soil surveys often consider only surface soil characteristics. Instead, a standard soil survey should be recognized as one that takes into account all the soil characteristics of both surface and underlying layers that significantly affect the response of soils to management. For economy this is better because an objective soil survey based on significant soil characteristics can serve to make various interpretations as required. Thus one objective soil survey can replace several interpretative surveys. This is more effective because the interrelationships of soil characteristics such as slope, texture, and depth combined with soil qualities such as fertility, erosion hazard, water-holding capacity, and permeability can be studied in combination so as to achieve good soil and water management according to the facilities available.

Reference is made to several previous reports[1] that have made valuable suggestions for soil survey work in India. Additional comments on these plus a few other principles on soil survey are:

1. Cooperative Center-State oriented soil survey program to serve all users. The advantages of a cooperative survey are that (a) better understanding would be achieved on a national scale between agencies that make soil surveys and those who use them. This should result in more support for the soils program among all levels of government as well as from the private sector; (b) specific plans for individual soil survey projects would be easier to formulate through a memorandum of understanding among cooperating agencies; (c) more available resources could be pooled to enhance efficiency of operations; (d) maps and reports would be somewhat standardized, thus would be more amenable for use across District, State, and survey area boundaries; (e) successful operating procedures resulting from the efforts of individual States or research institutions would have more widespread application among the various States; (f) the intimate detailed knowledge of local soil conditions can be integrated with a broad knowledge of the soils of the whole country, thus permitting more effective use of both.

2. Priorities of work - There is a need to inventory and classify all completed soil survey work into appropriate classes of reliability for specific uses. This should be followed by short-range and long-range plans for future surveys to coincide with a planned publication schedule. Revision or re-survey of some of the old areas should be a

part of the plan as needed to fit in with priorities established for current work on new project areas for intensive agricultural development. Priorities should be established cooperatively by all concerned at both Center and State levels of government in respect to urgency of work and resources available so that a planned schedule can be followed.

3. Soil testing laboratories - The work of the soil testing laboratories should be coordinated with a cooperative Center-State soil survey program. This should result in better interpretations and help to extend data on the relationships among soils, water, crops, and fertilizers from soil areas of known response to areas lacking such information.

4. Soil survey interpretations - These are estimates or predictions of how individual soils respond to particular combinations of practices for alternative uses. They are developed by relating to each kind of soil the results of research and especially the experience of cultivators. Many useful deductions can be made on a specific soils potential for producing crops under local conditions by observing what successful cultivators are doing. This kind of information should be readily extended to others having similar soil conditions and later improved on by knowledge gained from needed long-time scientific research as practicable.

This field of work needs special attention in order to get the maximum benefits from a soil survey program. Broad land use planning as well as detailed planning at the cultivator level for alternative systems of management by specific kinds of soil, can result from soil survey information. Specially trained officers are needed to promote this activity at all levels. At present, field workers have difficulty using soil survey information and consequently make only restricted use from some of the soil mapping. Commonly the absence of adequate soil descriptions make the accompanying analytical data difficult or impossible to interpret. Maps constructed in the office from soil pit information obtained on a grid pattern, commonly lack both soil descriptions and pertinent analytical data.

5. Soil correlation and classification - This should be a direct responsibility of the Center but in cooperation with the States. This activity cannot be done all at once but develop progressively along with the surveys. First, enough trial mapping must be done to test the legends. This provides information to revise soil descriptions to the extent they are adequate for soil classification and correlation. Eventually, the enormous soil work already done in India can be tied in with the world soil literature if soil classification and correlation progresses on a national basis. This will permit the Indian soil scientists to make better use of their own information as it applies to the experience and knowledge gained by soil scientists working on the same kinds of soils in other countries.

6. General soil maps - A need exists for a standard detailed soil survey on all agricultural lands in India. This will take a long time to complete. In the meantime, it may be possible to compile small-scale general soil maps for certain areas where sufficient information is on hand. These would be useful for broad land use planning of new irrigation projects, revision of old irrigation projects, reclamation projects, forestry work in catchment and other areas, new land development projects, and city industrial planning. The level of detail of soil information shown on the map, preferably having mapping units of phases of associations of soil series at a scale ranging between about 1:125,000 and 1:1,000,000, and the format of the legend and accompanying text should be designed so that administrators can have an easily understood map showing broad soil and land potentials for development.

7. Aerial photographs - Some aerial photographs are available. However, these are either restricted for use or cover such small areas of potential farm land that they are generally unavailable for use as soil survey base maps. Much wider coverage is needed.

8. Training - Soil surveyors are presently recruited from candidates with B.Sc. in Agriculture, Chemistry, Physics, or Geology. Many of the curricula, however, do not provide candidates with a good understanding of soil science and the supporting earth, physical, and biological sciences. Curricula specifically oriented in soil science are needed at the universities and agricultural colleges in both undergraduate and graduate programs.

(1) Kellogg, Charles E. - Soil Conservation and Soil Survey in India, 1958

Tamhane, R. V. et al, Report of the Committee on the Preparation of an Action Program for Comprehensive Soil Surveys in India, 1965

Mathur, R.N. et al, Report of the Study Team on Soil Testing and Fertilizer Use, 1963

Ford Agricultural Production Team - Report on India's Food Crisis and Steps to Meet It, 1959

WATER MANAGEMENT ON IRRIGABLE SOILS

The following recommendations are based on visits to States of Punjab, Uttar Pradesh, Maharashtra, Andhra Pradesh and Mysore in February and March 1966. These visits included discussions with State and local officials of agriculture and irrigation departments, inspection of irrigation systems, farm systems, research stations, and demonstration projects. Recommendations prepared by George C. Knierim, George L. McColm and Warren J. Leatham, USAID employees, were reviewed and considered in preparing this summary.

Some fundamental concepts need to be kept in mind in planning farm water management systems in India. The irrigation system must be well planned and the land levelled to permit control and uniform application of irrigation water in adequate amounts as needed. Control structures should be provided where needed.

A good drainage system is essential for intensive irrigation but this need has only recently been recognized in India and little work has been done. Waste water should be removed from each bund by waste disposal ditches. Deep intercepting and deep relief drains should be constructed to lower the ground water table where needed. Adequate main, lateral, and link drains should be planned and installed. Main ditches may be constructed on a progressive basis as the project is installed but adequate right-of-way should be provided in the project plans.

The principles of proper soil drainage should be applied. With few exceptions little has been done in India to provide good subsurface drainage systems. In many areas visited we observed the need for thorough investigations and orderly design procedures. In many projects the first step is to make a good drainage investigation. The source of the damaging water and the depth and material through which such water moves need to be determined. Hydraulic conductivity measurements, water table observations, piezometer studies, detailed soil borings as well as necessary topographic surveys must be made as required. Detailed procedures on soil drainage have been published in other countries. Many of these principles could be adapted and extended for use on similar soil conditions in India.

Irrigation Methods

Efficient irrigated agriculture depends on proper application of irrigation water in sufficient amounts and at the proper time. Crop varieties adapted to local soil and climate must be selected, then planted and cultivated properly. Soil amendments, fertilizers, and insecticides should be applied as needed. Water, soil and crop management practices should be based on the production of much higher yields than those now being obtained.

Some of the Indian irrigation systems were installed only to provide famine relief. These supply large areas of land with small amounts of water to avoid complete crop failures. Experiences in other countries have shown that intensive irrigation gives best results when water is applied in accordance with soil moisture and crop requirements. It is recommended that the advantages of intensive irrigation versus extensive irrigation be studied under local conditions.

Any system resulting in the use of adequate amounts of irrigation water per acre, which is essential to increased production, would require close cooperation with the Irrigation and Power Department of the Government. It would be necessary to demonstrate that intensive irrigation and good soil and water management would result in large increases in yields. Important changes would need to be made in the irrigation policies as well as agricultural practices. In some areas such as the Gangetic Plain farmers could obtain supplementary water from tubewells. In other areas medium and small reservoirs (tanks) for supplemental storage could be constructed.

Indian Soil Conservation technicians have carried out an extensive program on installation of bunds. These technicians could be trained to lay out contour borders for irrigation in accordance with standard procedures. Also, they could plan and lay out drainage ditches. We observed some good systems laid out in this manner with the aid of American advisors. The installation of properly designed bunds to mark border strips would control the water to some degree. Cultivators could then work on the problem of establishing a level grade across its width using floats or scrapers drawn by oxen, which is usually the only power available.

A major job of U.S. technicians should be to work with the Indian staff to secure widespread lay-out of water management systems on lands where wild flooding is being practiced, and on lands which are to be newly irrigated. This should be accomplished by on-site technical help.

Construction specifications and procedures need to be worked out for local conditions. Irrigation and drainage guides should be developed in each area to provide specific dimensions and criteria for installation of water management systems adapted to the local soils, crops and climate.

The installation of water management systems could be started as soon as qualified engineers are added to the GOI staff to provide leadership in such work, policies and instructions issued, and field staffs are trained. Progress in the field would depend on how rapidly Indian technicians could be trained and on funds made available for the work.

Water Management in Punjab and Uttar Pradesh

Water management problems were studied in the Punjab and Uttar Pradesh through (a) visits to farms and projects, February 1 to 12; (b) discussions with officials; and (c) review of reports. There are many opportunities for increased food production in areas of the Gangetic Plain where the soil is suitable for intensive agriculture with proper soil and water management. The climate permits two or three crops a year. A large body of ground water underlies much of the Plain. The availability of ground water gives the area a great advantage for future irrigation development. This contrasts with the meager ground water thought to be available in much of the Deccan Plateau.

Large areas have been irrigated by surface water supplies and by tubewells but additional water is needed generally to provide sufficient amounts for intensive crop production. More water can be made available by pumping from tubewells. Increased agricultural production may be obtained by better soil management practices, improved water management including farm irrigation and drainage, and through reclamation of saline and alkali soils. The first step is to provide an adequate water supply with drainage and flood control measure where needed.

Problems and Needs in Water Management

The following problems and needs in water management were observed:

1. Need for developing additional supplies of irrigation water through tubewells or storage. Such supplies are needed to irrigate lands not now irrigated and to supplement supplies of existing irrigation systems.

2. Need for better farm water management. In many projects the command area where irrigation was being attempted was much too large. There is need to level the land and irrigate efficiently to reduce waste of water. There is need to plan farm irrigation systems on the basis of topography and soils instead of existing farm boundaries. Better water management is needed in both major and minor irrigation projects. This problem has been covered in the report "Land and Water Resources in India" by John Spencer, Ellis Hatt and Norman Tripp published by AID in 1964.

3. There is need to apply soil and water conservation principles in many tubewell projects. The command areas of most tubewells visited were much too large for intensive irrigation. Typical tubewells were designed for discharge of 1.0 cu. sec. or less for a command area of 500 to 1000 acres. This seemed to be based on existing farm irrigation facilities and on the customs of the farmers. The economy and

feasibility of larger tubewells should be tested by field trials.

It was reported that to speed up the tubewell program additional deep-well drilling equipment (600-800 ft. depth), compressors, efficient pumps and motor equipment, and repair parts and facilities were needed. American-made or comparable equipment should be installed if demonstration projects are approved which require tubewells. A private engineering firm experineced in such work should be employed to design, supervise installation, and train operators in maintenance and repair.

4. There is also a need for an active program for reclamation of saline and alkali soils. Research has demonstrated that saline and alkali soils can be reclaimed by one or more of following measures; application of organic matter, gypsum or other soil amendments, flooding after bunding, subsoiling, deep plowing, growing paddy (rice) and drainage. Field trials should be made to establish feasibility and costs, and practicability of alternative measures. The soils which may be reclaimed most readily and economically need to be mapped. Demonstration projects should be undertaken first on those areas which can be most easily reclaimed.

5. Drainage is the first step in reclamation of saline and alkali soils. Surface drainage is needed to remove excess surface and waste water. Link drains are needed to connect farm drains with major drains. Subsurface drainage may be obtained by lowering ground water levels by pumping, by deep tile, or by deep open drains. Pumping will play an important part in subsurface drainage. Tubewells lower the water table and can provide adequate drainage in many areas.

Soil drainage is necessary in many locations to obtain improved crop production. Provision for drainage is in the Fourth Five-Year Plan. Accomplishments in farm drainage are very limited and this activity needs much greater effort. In Punjab State the Ministry of Power and Irrigation has planned and constructed some major drains and laterals. No drainage construction was observed in Uttar Pradesh State. Drainage and flood control systems should be designed to remove excess rain during the monsoon season.

Water Management of Black Cotton Soils

Black cotton soils are extensive in the States of Maharashtra, Gujerat, Madhya Pradesh, Mysore and Andhra Pradesh. Proper handling of such soils under irrigation is a difficult problem. These clayey soils have slow permeability, are sticky and plastic when wet and crack deeply on drying. With adequate moisture they are productive, but can be cultivated only within a fairly narrow moisture range. They are either too sticky and plastic when wet or too hard when dry for easy tillage. These soils are mostly calcareous and usually not seriously salt affected unless irrigated.

When such soils are irrigated excess salts may rise to the surface. This commonly occurs where the water table is less than 5 feet below the ground surface. Where sodium dominates the exchange complex, soil structure breaks down and may make the soil unfit for ordinary crop cultivation. We observed fields where this had occurred and it was thought the process had progressed so far that reclamation was not economically feasible. When this condition is reached the permeability of the soil is almost nil and the drainage and reclamation would be too costly to be practical.

Good soil and water management, including drainage, are absolutely necessary for the successful cultivation of black cotton soils under irrigation. Many of these soils have slopes of one to three percent. Soils in the middle and upper parts of the slope are less likely to become waterlogged than those at the bottom of the slope. Due to slow permeability and relatively flat relief, excess water accumulates at the bottom of the slopes and commonly causes a high water table. Drainage is required if the water table is within about 5 to 8 feet of the soil surface during any period of the year when crops are growing. Black cotton soils with permeable substrata and those managed to permit abundant root growth, usually have less hazard of waterlogging and subsequent drainage by excess salts.

Land leveling is usually required on these soils to obtain good water management. Where wild flooding is used to irrigate, some soil will remain dry and depressional areas will be flooded. An even application of irrigation water and prompt removal of excess water by means of field drains are essential to avoid excess flooding.

Black cotton soils have poor physical characteristics for dry land farming and even worse for irrigated farming. Consequently, very careful water and crop management, combined with proper tillage practices, needs to be followed. Unfortunately, the best combination of practices needed for these soils is not well known. Infiltration and permeability rates together with crop consumptive use requirements need to be determined in order to design water management systems for specific sites. There is an immediate need to analyze and use all research information available as well as that known by successful cultivators. At the same time, research work on the management of black cotton soils should be increased at the research stations, and through field trial demonstrations. Enough information should be made available as soon as possible to prepare irrigation, drainage, and crop management guides on black cotton soils, for the use of individual cultivators.

Selection of Areas for Demonstration Projects

On the basis of only five States visited, it is the recommendation of the team that tentative selection of demonstrations be considered in the following States in the following approximate order of priority.

(1) Uttar Pradesh (2) Maharashtra

(3) Andhra Pradesh (4) Punjab

Before final selection by the GOI of States and specific sites within States, it is recommended that evaluations be made by a party of three men. The team should be composed of an engineer, economist, and soil scientist. The purpose of the evaluation would be to suggest the scope of the project, outline problems to be solved, propose goals for accomplishment and recommend suitable areas for reaching objectives.

Members of the team will be experienced technicians selected as the Inventory Team.

In the meantime, tentative discussions of location should keep in mind the following criteria:

1. State has indicated a desire to participate.

2. Must have strong support at State level, including

   (a) willingness to establish a focal organizational point of responsibility,

   (b) willingness to support necessary legislation,

   (c) willingness to furnish necessary competent Indian staff.

3. The areas selected must have strong opportunities for substantial progress within the time period of the project.

   (a) adequate water supply,

   (b) soils with capability for intensive management,

   (c) problems representative of larger areas,

   (d) with good management could produce a favorable return,

   (e) willingness and probable ability of owners to participate.

4. Must be suitable to serve all purposes of project.

   (a) increase production,

   (b) demonstrate improved management practices to cultivators,

   (c) training of technical counterpart staff.

5. Must have suitable housing for USAID-financed personnel.

Uttar Pradesh

The objective should be to locate an area that would be representative of the large body of irrigated valley land where it would be possible to demonstrate possibilities for intensive agriculture through supplementing water supply with tubewell development, and where there is also possibility of immediate improvement through drainage. Soils should be at least moderately deep, medium textured, not severely affected by harmful salts and where there is reasonable opportunity to successfully drain waterlogged area.

The survey should be made in the triangular area between Allahabad, Lucknow, and Kanpur.

The results of tests and demonstrations in this area could be expanded to approximately 9 million acres of similar lands within the State.

Maharashtra State

The objective in this State would be to locate an area of deep or moderately deep cotton soils with a reasonable potential for drainage and with water available for irrigation.

We suggest that the survey be made in vicinity of Poona, giving consideration to areas along the Godavari, Bhima, and Nira Rivers. A project of approximately 5,000 acres would be representative of a larger area of approximately one million acres to which results could be extended.

Andhra Pradesh

The objective in this State would be to locate a demonstration on a project currently in the process of development. The right bank canal of the Nagarajunsagar project is now near completion and offers an opportunity to develop a demonstration in a newly irrigated area.

The area selected should include both black and red soils. It would provide a demonstration which could be expanded to the entire irrigation project of approximately 3 million acres.

Punjab State

The objective in Punjab would be to select an area under an existing canal where it would be possible to supplement water supply from tubewells, and where farm drainage could also be demonstrated. Consideration should be given to Ludhiana District and in Karnal District, south of Chandigarh. Either of these areas would be representative of approximately 3 to 5 million acres.